APPLICATIONS OF NUMERICAL MODELS IN THE COASTAL, SEMI-ENCLOSED, AND MARGINAL SEAS USING THE RELOCATABLE MODELING ENVIRONMENT

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LONG-TERM GOALS

To provide the Navy's R&D and operational communities with the means to rapidly relocate, test, and transition increasingly complex numerical models of coastal, semi-enclosed, and marginal seas, that can be configured to run in any region of the world's ocean with relative ease.

OBJECTIVES

To develop, comprehensively test,and validate a 2-D tidal and storm surge coastal seas models with the entire process integrated into a relocatable modeling environment (RME) provided under a graphical user interface (GUI).

APPROACH

Modern computer technology can simplify much of the effort required to relocate a numerical model in a new region of interest. In this project which is a complimentary effort with the University of Colorado (CU), CU is developing the ocean models under separate ONR sponsorship, and in particular CURReNTSS (University of Colorado Rapidly Relocatable Nested Tide Storm Surge) which is a 2-D, nestable, data-assimilating model found to be quite accurate in depicting tidal sea surface height (SSH) in areas of Navy interest. The CAST role is to develop and test appropriate tools under the RME with a user-friendly GUI that will enable the modeler to rapidly relocate the models to any region of the world.

WORK COMPLETED

CURReNTSS had been successfully validated by CU against tidal station data and sea level observations in the past (see Reference 1), and only the barotropic currents needed to be validated in FY97. To ascertain the versatility of the model in its ability to accurately predict barotropic tidal currents in two varied and complex regions of interest, validation exercises were performed with observational data in the Yellow Sea and the North Atlantic Bight. For the coastal and shallow waters of the Yellow Sea, the barotropic influences weigh heavily. An enhanced version of the CURRenTSS model, which is now capable of assimilating altimetric tidal gage data, e.g. from TOPEX, for improved predictions of tidal elevations and currents, was implemented in the Yellow Sea at a resolution of 1/5 degree. The gridded domain extended from 117 to 131 degrees

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East and from 24 to 41 degrees North as shown in Figure 1. The grid resolution resulted in a 71 by 86 grid. The bathymetry was interpolated from a 1/6 degree Korean topographical database and other high resolution accurate databases provided by NAVOCEANO. The GUI provided data from 31 tidal stations which were assimilated into the model with a fixed weighing parameter (0.9). Global results available via the GUI were used to setup the boundary conditions for the open boundaries (south and east) and eight primary linear tidal constituents were included, namely M2, S2, N2, K2, K1, O1, P1, and Q1.

RESULTS

The North Atlantic Bight has some of the highest tidal ranges and fastest tidal currents in the world. CURReNTSS was run in a nested fashion at two different resolutions. The larger coarser domain at 1/12 degree covered the entire bight from 77 to 63 W and from 35 to 45 N (see Figure 1). The nested high resolution fine grid at one minute resolution, which mainly covered the Bay of Fundy and some parts of Gulf of Maine, extended from 68 to 64 W and from 44.5 to 45.5 N. The coarse resolution model was run first for ten days with astronomical forcing alone. An accurate bathymetry was generated by fusing ETOPO5, half minute NOS data, and an accurate (half minute) USGS topographic database. The boundary conditions were provided from the GUI as before, and tidal station data from 144 gages in the region were assimilated into the model. The model results were saved at the boundary of the nested fine grid. Next, the fine grid model was run with boundary conditions provided from the encompassing coarse model for ten days under similar forcing.

The model was run for a period of twenty days in the Yellow Sea and forcing was provided from astronomical tides alone. A time series of induced tidal currents was obtained from the model output and compared against observed tidal currents at the nearest available location. The model results compared favorably with the observed values as shown in Figure 2. The predicted tidal current phases matched well though some discrepancies were found in the magnitudes (see Reference 2). These can be attributed to the fact that the model value represents the average value of the current over the grid-cell and not at a fixed point in space. Also, the model predicts depth-averaged currents unlike the observations which were obtained at a fixed depth of approximately 70% of the total depth.

The predicted tidal currents at points fixed a priori were used to calculate tidal ellipses and compared against published Moody charts data for the North Atlantic Bight. The magnitudes of tidal ellipses (major and minor axes) matched well along with tidal current phases and tidal ellipse orientations.

IMPACT/APPLICATIONS

For model evaluation and comparison purposes, ADCIRC Finite Element Model output will soon be integrated into the RME if desired by NAVOCEANO, and be validated against available observational data and other appropriate criteria. Inter-model comparison between CURReNTSS and ADCIRC will also soon be performed if desired by NAVOCEANO. While these tasks were scheduled to be completed in FY97, they were delayed owing to NAVOCEANO's decision to stop further development of ADCIRC model for new regions. NAVOCEANO has opted to use

CURReNTSS in new regions to meet its operational needs for tidal predictions. At present, ADCIRC complements CURReNTSS.

The FY97 emphasis was to complete all tasks pertaining to the 2-D version of CURReNTSS which has now been fully validated. For FY98, the emphasis will be on the applications and validation of the 3-D baroclinic model. The approach will be the same as for the 2-D model. It will use data assimilation to force realism and a relocatable-nestable capability will be provided under a GUI. The RME will be enhanced to support sigma co-ordinates and vertical boundary conditions. Similar validation studies will be conducted with observational datasets.

The comprehensive RME/GUI is a valuable tool for Navy modelers. In the long-term, all related numerical oceanographic and atmospheric models (tides, waves, surf, circulation, thermal, and forcing) that are regional or local in scale, will be integrated into the RME/GUI. This will not only improve their utility but will also significantly reduce the learning curve for Navy operational users.

TRANSITIONS

The 2-D tides and storm surge models, as well as an enhanced RME and GUI, have been implemented at NAVOCEANO. The RME, as a separate application, can also be used in a stand-alone mode to provide a GUI for editing bathymetry and tidal station data sets.
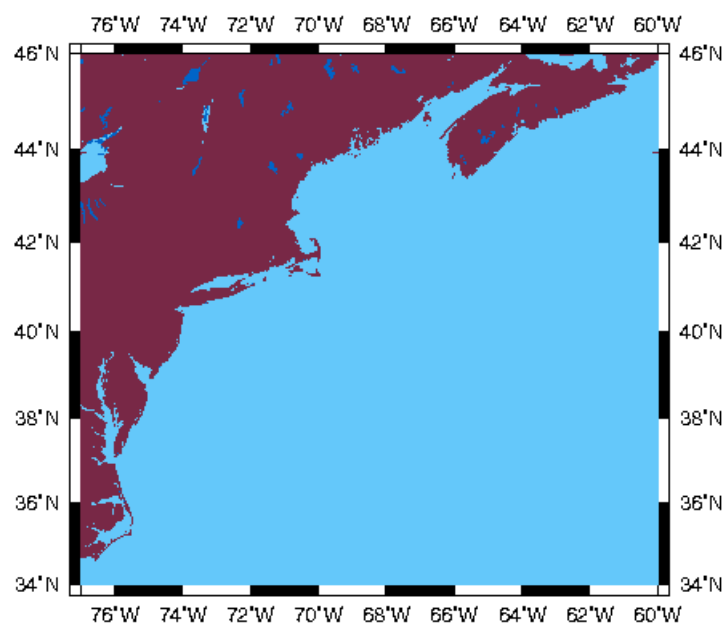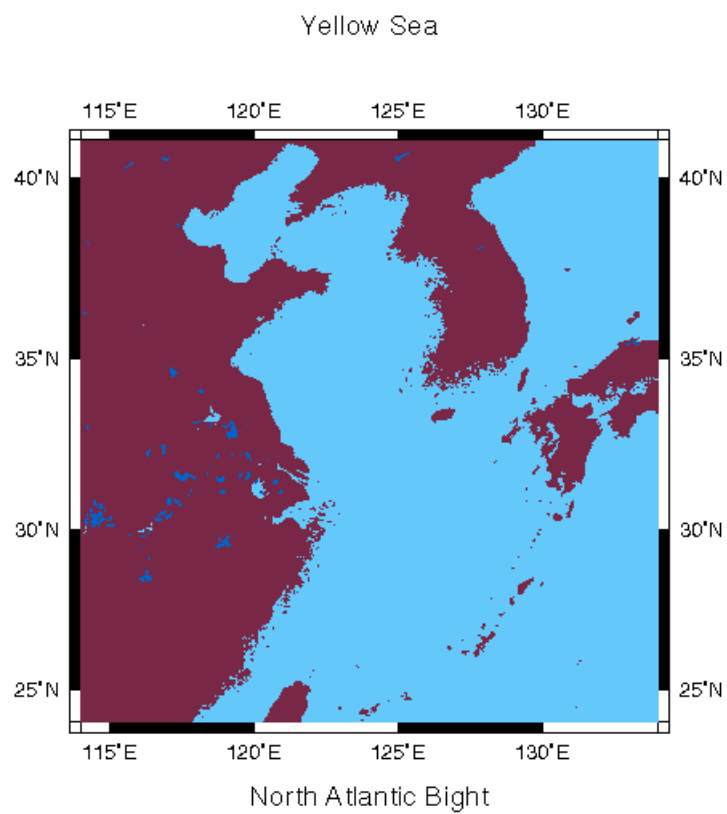
RELATED PROJECTS

Transition and implementation of the Tidal Relocatable Modeling Environment (RME) at the Naval Oceanographic Office under NASA Contract NAS13-564 Delivery Order 125.
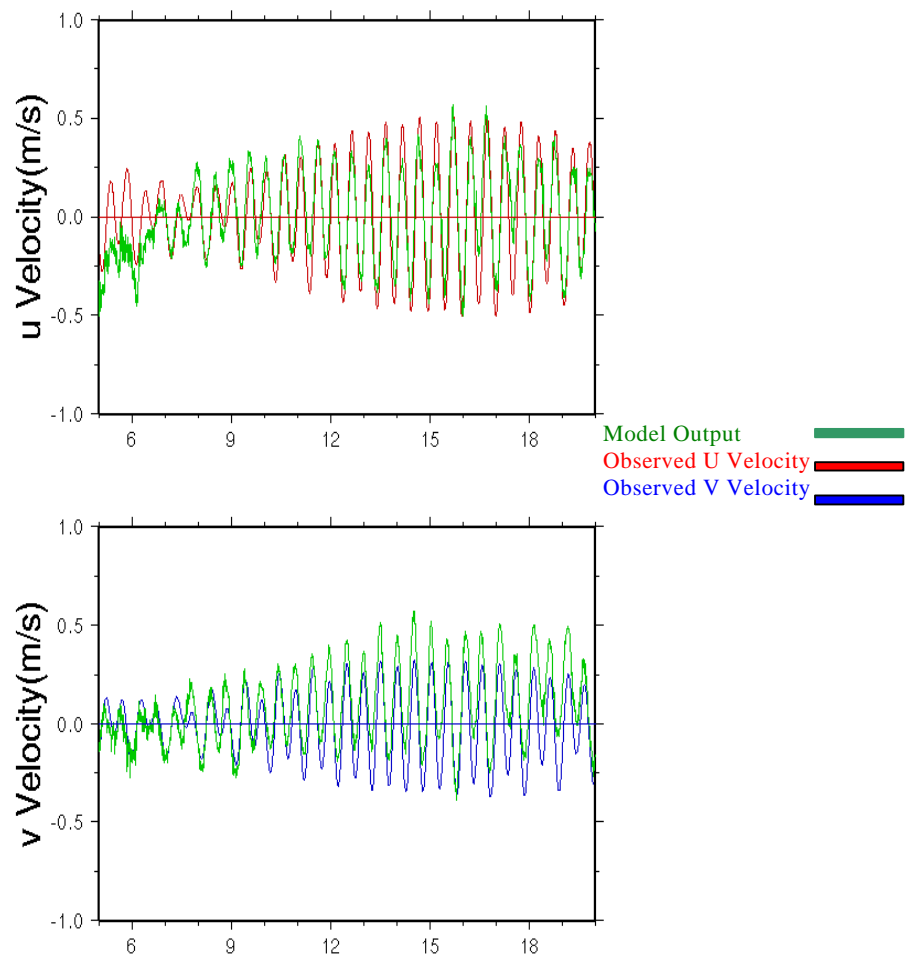
The ONR contract with Dr. L. Kantha at the University of Colorado for model developments.

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Yellow Sea

North Atlantic Bight

Figure 1

Figure 2.